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(54) A SUBMERSIBLE POWER CONVERTER

(71) We, WALTER LEE CHAPPELL and JOHN DAWSON WATTS, of 4422 Cheena, Houston, State of Texas 77096, United States of America, and 307 Thicket, Houston, State of Texas 77079, United States of America, respectively, both citizens of the United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

This invention generally relates to the field of power generators and more specifically to the field of generation of power by positioning a power-generating mechanism in ocean current or other flowing water for the purpose of causing the flow of current to drive a plurality of vanes, thus producing mechanical work and converting the mechanical work into electrical, mechanical, hydraulic or other type power capable of being stored and used.

At the present time it is well known that the known naturally occuring energy sources such as wood, coal, fossil fuels are diminishing at a more rapid rate than they can be naturally or artificially replaced or replenished. It has therefore become necessary to consider other types of energy sources, such as nuclear energy sources and naturally occurring sources, such as wind, sun, steam, rising and falling tides and water current.

The present invention is directed to the utilization of one such naturally occurring or artificially induced energy sources - water current, for the purpose of generating energy.

The use of submersible power generators for converting the energy of deep ocean currents, tidal flows and the like to more usable forms of power such as electricity is known. For example, United States patents 2,501,696; 2,820,148; 3,603,804; 2,871,790; 3,064,137; 3,200,255; 2,501,696; 1,393,472; 1,475,170. 3,192,937; 3,870,893; 3,882,320; 3,912,938; 3,898.471; 3,758,788; 3,746,875; 3,744,048; 3,697,764; 3,808,445; 3,783,302; 3,064,137 and 3,426,540 all disclose patents utilizing tides, wave action or flowing water currents for generation of power.

None of such prior art patents disclose a means for increasing the velocity of the existing flowing water current to thereby achieve and cause an increase in the velocity force of said current which thereby causes a higher work force. Such increase in fluid flow thus causes an increase in the power output of such a power generator.

According to one aspect of the present invention we provide a method of converting the power in flowing water, comprising the steps of:

forming a housing having walls which utilize the following method steps,

forming an inlet opening in an inlet section, mounting a power section downstream of the inlet section with an aperture running the length of the power section to form a passage, and mounting an outlet section downstream of the power section and forming an outlet opening therein, the outlet opening having a cross-sectional area greater than that of the inlet opening to decrease the velocity of the water exiting the device below that of the water entering while increasing the pressure of the water flowing through the housing;

forming a power member having a shaft and a plurality of blades mounted with said shaft, the blades extending outwardly and, for at least part of their length, helically of said shaft;

mounting said power member within said power section of said housing for movement by the flowing water;

positioning the housing and power member in the flowing water to restrict a portion of the water through the housing;

extracting kinetic energy from the water passing through the housing from the action of the water impinging on the blades which imparts rotation to the shaft; and

converting the rotation of the shaft into usable power.

According to another apect of the invention we provide a sumbersible device for use in converting the power provided in flowing water, comprising:

a power member capable of being moved by flowing water, said power member including a shaft and a plurality of blades mounted with said shaft, the blades extending outwardly and, for at least part of their length, helically of said shaft;

generating means mounted with said power member for converting the movement of said power member into usable power; and

a housing mounted around said power member for restricting a portion of the flowing water, said housing having walls which define

an inlet section forming an inlet opening, a power section mounted downstream of the inlet section, said power section defining an aperture running its length to form a passage with said power member mounted therein, whereby, in use, the water flowing through the power section impinges upon the blades of said power member to rotatably move said blades and impart rotation to said shaft, an outlet section mounted downstream of the power section forming an outlet opening, the outlet opening having a cross-sectional area greater than that of the inlet opening for decreasing the velocity of the water exiting the device when in use below that of the water entering while increasing the pressure of water flowing through the housing and thereby permitting extraction of kinetic energy by said power member from the restricted portion of flowing water for conversion into usable power by said power generating means.

Described below are preferred forms of power generator for installation in flowing water currents wherein such generator includes a suitable anchored plurality of outwardly extending spiral vanes mounted with a power shaft wherein rotation of such vanes by the flowing current imparts rotation to the shaft, said shaft being mounted with a suitable apparatus for converting rotation of said shaft into suitable energy such as mechanical, hydraulic or electrical energy.

The shaft and vanes are suitably mounted in housing structures which cause the water current to flow from an area of low velocity head to an area of higher velocity head and thereafter to an area of lowest velocity head which thus enables the water positioned in the latter area to quickly escape. The increased velocity of the water in the higher velocity head area thus imparts a greater mechanical work force on the rotating vanes and shaft to thereby impart a greater power force to a suitable apparatus such as a turbine generator, to thereby cause greater electrical power to be generated than would normally be generated through a naturally occuring current flow.

Figure 1 is a cross-sectional view of one embodiment of the present invention illustrating a housing structure, spiral or helical vanes or blades;

Figure 2 is an elevated view of the spiral or helical blades or vanes and the shaft mounted therewith.

Figure 3 is a cross-sectional side view of yet another embodiment of the present invention illustrating a housing and spiral or helical blades extending outwardly from a shaft;

Figure 4 is a top cross-sectional view of the invention illustrated in Figure 3 illustrating the position of an inlet and outlet section of the present invention relative to the spiral or helical blades.

Referring now to the drawings and as illustrated in Figure 1, a power generator is generally indicated by the numeral 10 and includes a housing illustrated generally at 12. The housing 12 includes an inlet section 14, power generator section 20 and exhaust section 42 and is generally positioned such that water current as illustrated by the arrows C_1 passes through the sections of the housing 10 wherein such current exits from such housing 10 as illustrated by the arrows C_2.

The inlet section 14 includes an inlet opening 16, generally tapered sidewalls 14' and power section opening 18. It should be noted, and as illustrated in Figure 1, that the opening 16 is larger in diameter than the generator section opening 18.

The power generator section 20 includes the opening 18 and outlet opening 22, which opening enables the generator section opening 20' defined by the turbine section walls 20 to communicate with the opening 42' defined by the tapered side walls 43 of the exhaust section 42.

As illustrated, the power section 20 may be of generally cylindrical configuration or other suitable shapes and also includes a pair of support members or braces 26 and 28 mounted and suitably attached to the interior of the tapered wall portions 14 and 43, respectively for supporting a power member generally illustrated at 24 and shown and illustrated with further clarity in Figure 2. The power member is suitably mounted at each end 34' and 36' with the support members 26 and 28 respectively for positioning longitudinally with respect to the power section opening 20' and further includes suitable bearing members 34 and 36 mounted with said support members 26 and

28 respectively for the purpose of supporting such power member 24 and to enable its rotation thereof in a manner to be brought out hereinafter.

The power member 24 includes a shaft member 38 and a plurality of helical or spiral vanes or blades 40 which extend helically outwardly from such shaft 38 such that when such power shaft 24 is positioned in the housing 10 as illustrated in Figure 1 in the opening 20' and supported by the cross members 26 and 28, the current C_1 entering through the opening 18 impinges and contacts the blades 40 to impart rotation in a direction as illustrated by the arrows 40' to the blades 40 and the shaft 38. Because of the increased velocity of the current C_1 entering through the opening 18 into opening 20', the rotation of the member 24 is greater than such rotation would be if the member 24 were positioned without such housing 10 in normal current flow.

As further illustrated in Figures 1 and 2, a suitable generator mechanism 30 is suitably mounted adjacent the bearing member 34, so that rotation of the shaft 38 imparts rotation to the rotatable portion (not shown) of the generator 30 which is well known in the art. While such power generated may be of any suitable type, such as mechanical, hydraulic or electrical, for the purposes of this embodiment, suitable electrical conductors 32 are connected with the generator mechanism 30 and are connected their other end (not shown) for the purpose of conducting electrical power that is generated to desirable locations of use.

As further illustrated in Figure 1 and set forth hereinabove, the exhaust section 42 includes the tapered side walls 43, opening 22 and opening 29 to define the cavity 42'. For the purpose of further enhancing the flow of current through the generator section 20', the exhaust section 42 is illustrated as being larger in diameter than the generation section 20 and, in the preferred embodiment, the largest diameter of the exhaust section 42, such as at 29, is larger than the largest diameter of the inlet section 12, such as at 16. The difference in diameter causes a pressure increase in the current as it moves from the generator section to the exhaust section 42. Such increase in pressure in the current flow moving from the generator section 20' to the exhaust section 42' causes the velocity of the current to decrease such that current flow C_2 exiting from the opening 29 is flowing at a smaller velocity than the current exiting from opening 28 which thereby further enhances current flow out of the generator section 20.

As set forth hereinabove, the power generator device 10 is designed for use under submerged conditions and in view of the fact that such device 10 may be a large structure for generation of a large amount of power, it is desirable to facilitate bringing the device 10 to the surface of the water in order that it may be readily repaired and serviced. It may also, on occasion, be desirable to cause rotation of the power generator 10 90 degrees in either direction for the purpose of allowing either the shaft 38 and bearings 34 and 36 to be repaired and serviced without requiring repair services to be conducted in submerged conditions. Accordingly, it is desirable to provide the housing 10 with at least one, and preferably a pair, of flotation chambers such as illustrated at 46 and 48. The flotation chambers may be defined by welding or otherwise connecting an outer housing structure 50 to the inlet or exhaust portions 14 and 42, respectively, thereby defining an annulus into which air may be introduced to render the power generator 10 buoyant. Air may be introduced through valve devices 52 and 54, if desired, and removable plug devices 56 and 58 may be removed from the outer housing structure 50 as desired to allow interchange of water for ballast.

For the purpose of facilitating rotation of the housing structure to allow the bearings 34 and 36 or generator 30 to be serviced and/or repaired in a non-submerged enviroment, an internal wall structure 60 may be provided dividing the internal water or air chamber and defining the chambers 46 and 48. Air then may be introduced into one of the chambers 46 or 48 through the respective valves 52 or 54 with one of the plugs 56 or 58 removed, thereby causing one extremity or the other of the housing structures to become more buoyant. When this ocurs, the more buoyant extremity of the housing structure will cause rotation of the generating mechanism to occur. The floating of the generator mechanism on the body of water may be effectively controlled in this manner and servicing operations may be effectively conducted at much less expense than would be required if repair operations were necessitated in a submerged environment.

Referring now to Figures 3 and 4 of the drawings, yet still another embodiment of the present invention is illustrated which incorporates a power generator generally illustrated at 62 and includes a rotatable shaft member 78 positioned such that the longitudinal portion of the shaft 78 is normal or transverse to the flow of current C_1' and C_2'.

The power generator as illustrated at 62 and in Figures 3 and 4 also includes a housing structure illustrated generally at 64 having an inlet section 66, a generator section 68 and an exhaust section 70. The inlet section 66 defines an inlet opening 72 having tapered side walls 72' and a power inlet section opening 74 of smaller diameter

than the opening 72. Since the opening 74 is smaller than the opening 72, current C_1' flowing through the inlet section 64 is at a greater velocity when it enters the opening 74 than when it enters the opening 72 to thus provide more power through increased velocity of current flow to drive and rotate the shaft 78 by imparting rotation to a plurality of helical or spiral blades or vanes 92 and as explained hereinabove in relation to Figure 1.

The generator section 68 of the housing structure 64 is constructed to define a substantially cylindrical internal power compartment 76 for receiving the shaft and blades 80 and 92, respectively and as further illustrated and explained hereinabove in Figure 1.

The shaft 80 may be supported at one extremity thereof by a bearing member 78 supported by cross member 84 connected to the anterior wall structure of the housing 62 as illustrated in Figure 4. At the end opposite the cross members 84, the shaft 80 may be journalled or otherwise suitably supported by the anterior wall section 72' such that rotation of the shaft 80 imparts rotation to the rotatable part of the generator mechanism 86 which converts such energy into electrical energy for conduction through the electrical outlets or wires 88 for the purpose of conducting electrical power to any suitable facility for use. Of course, it is to be understood that while Figures 3 and 4 disclose the use of the power generator 62 for conversion into electrical energy, that such energy might also be converted into mechanical and hydraulic energy uses.

The exhaust section 70 of the housing structure illustrated in Figures 3 and 4 tapers outwardly from the section 72' to the exhaust opening 90 with such opening 90 being of greater diameter than the opening 72. As in Figure 1 this feature causes a velocity drop to occur between the generator section 68 and the exhaust section 70 which enhances the flow of current out through the opening 90 as illustrated by the arrows C_2'.

As illustrated in Figure 4, the inlet opening 72 of the housing structure is not in direct alignment with the exhaust section 70 but, in fact, is offset therefrom such that the power section 68 is positioned transverse to the longitudinal alignment of the inlet section 66 and exhaust section 70. Due to the fact that the inlet section 66 and exhaust section 70 are offset relative to each other, the exhaust section 70 is thus enabled to function without any current turbulent flow that might otherwise be created by current flow C_1' past the inlet section 66 of the housing.

The offset nature of the housing 62 further facilitates utilization of blades 92 that are of two different configurations as illustrated at 92 and 92a, thus, as illustrated in Figure 4, the blades 92 which receive the current C_1' through the opening 74 are straight and not helical and the portion of the blades 92a extending inwardly into and adjacent the opening 72" extend helically outwardly from the shaft 78 such that current flow C_1' hitting the blades 92, which are maintained normal to the current flow C_1' impart rotation to the shaft member 78 and the current flow is then turned at a 90 degree angle and continues to flow toward the opening 72" but due to the helical blades 92a a further rotation is imparted to such shaft because of the relationship between the current flow and the blades 92a maintained at an angle to the current flow passing towards the opening 72'. As the current flow enters the opening 72" and through the exhaust 90 in the direction of the arrows C_2', due to the fact that the diameter of opening 90 is larger than the diameter of 72', to thereby cause a velocity drop in the water at the opening 90 relative to the power section 68, the flow current is given more room for flowing outwardly of the opening 90 which means that such flow current is enabled to leave the housing exit 62 at a lower velocity than would normally occur if, for example, the exit opening 90 were of the same diameter as the power section 68.

In view of the foregoing it should be apparent that preferred forms of the present invention provide an efficient means for generating power through the energy of flowing water currents whether such currents be ocean currents, river currents, man-made currents and the like. By submerging such power generator well below the level of the surface of the water and the power generator will be effectively protected from storm damage and other hazards.

WHAT WE CLAIM IS:-

1. A method of converting the power in flowing water, comprising the steps of:

forming a housing having walls which utilize the following method steps,

forming an inlet opening in an inlet section, mounting a power section downstream of the inlet section with an aperture running the length of the power section to form a passage, and mounting an outlet section downstream of the power section and forming an outlet opening therein, the outlet opening having a cross-sectional area greater than that of the inlet opening to decrease the velocity of the water exiting the device below that of the water entering while increasing the pressure of the water flowing through the housing;

forming a power member having a shaft and a plurality of blades mounted with said shaft, the blades extending outwardly and,

for at least part of their length, helically of said shaft;

mounting said power member within said power section of said housing for movement by the flowing water;

positioning the housing and power member in the flowing water to restrict a portion of the water through the housing;

extracting kinetic energy from the water passing through the housing from the action of the water impinging on the blades which imparts rotation to the shaft; and

converting the rotation of the shaft into usable power.

2. A method according to claim 1, including the step of providing an outside wall on said housing displaced from the inside walls to hold a sufficient quantity of air to provide neutral buoyancy to the device when submerged within the flowing water.

3. A method according to Claim 1 or 2, including the steps of

forming the passage in said power section to have a cross-sectional area less than that of the inlet and outlet openings,

forming the walls of the inlet section to flare inwardly from the inlet opening toward the power section, and

forming the walls of the outlet section to flare outwardly from the power section toward the outlet opening.

4. A method of converting the power in flowing water, comprising the steps of:

forming a housing having walls which utilize the following method steps,

forming an inlet opening in an inlet section, mounting a power section downstream of the inlet section with a power member mounted therein, mounting an outlet section downstream of the power section and forming an outlet opening therein, the outlet opening having a cross-sectional area greater than that of the inlet opening for decreasing the velocity of the water exiting to below that of the water entering while increasing the pressure of water flowing through the housing, and positioning the inlet section and the power section transversely relative to each other and having a power section opening therebetween for enabling water flow through the inlet section into the power section;

forming a power member having a shaft and a plurality of outwardly extending blades,

rotatably mounting the shaft of said power member longitudinally in the power section and each said blade is formed with a first section positioned transversely to the flow of water through the power opening and a second section which is at least a portion of a helix is positioned parallel to the flow of water through the power section;

positioning the housing and power member in the flowing water to restrict a portion of the water through the housing;

extracting kinetic energy from the water passing through the housing to rotate the shaft by having the restricted portion of water hit the first section of each blade, turning the water flow in said power section to flow longitudinally therethrough and further rotate the shaft by hitting the second section of each blade while flowing longitudinally through said power section; and

converting the movement of the power member into usable power.

5. A submersible device for use in converting the power provided in flowing water, comprising:

a power member capable of being moved by flowing water, said power member including a shaft and a plurality of blades mounted with said shaft, the blades extending outwardly and, for at least part of their length, helically of said shaft;

generating means mounted with said power member for converting the movement of said power member into usable power; and

a housing mounted around said power member for restricting a portion of the flowing water, said housing having walls which define

an inlet section forming an inlet opening, a power section mounted downstream of the inlet section, said power section defining an aperture running its length to form a passage with said power member mounted therein, whereby, in use, the water flowing through the power section impinges upon the blades of said power member to rotatably move said blades and impart rotation to said shaft, an outlet section mounted downstream of the power section forming an outlet opening, the outlet opening having a cross-sectional area greater than that of the inlet opening for decreasing the velocity of the water exiting the device when in use below that of the water entering while increasing the pressure of water flowing through the housing and thereby permitting extraction of kinetic energy by said power member from the restricted portion of flowing water for conversion into usable power by said power generating means,

6. A device according to Claim 5, wherein the blades of said power member form a helix around the shaft and said shaft is disposed longitudinally of said passage formed in the power section.

7. A device according to Claim 5 or 6, wherein said passage formed in the power section has a cross-sectional area less than that of the inlet and outlet openings and said walls of the inlet section flare inwardly from the inlet opening toward the power section and said walls of the outlet section flare outwardly from the power section toward the outlet opening.

8. A device according to Claim 5, 6 or 7,

wherein said power generating means inludes electric power generating means and has electric power conducting means connected to transmission means for use in generating electrical power.

9. A device according to any one of Claim 5 to 8, wherein said housing has inside walls which define the inlet, power and outlet sections and an outside wall displaced from the inside walls to hold a sufficient quantity of air to provide neutral buoyancy to the device when submerged within flowing water.

10. A submersible device for use in converting the power provided in flowing water, comprising:

a power member, having a plurality of blades mounted with a shaft, the blades extending outwardly and, for at least part of their length, helically of said shaft;

generating means mounted with said power member for converting the movement of said power member into usable power; and

a housing mounted around said power member for restricting, in use, a portion of the flowing water, said housing having inside walls which define

an inlet section forming an inlet opening, a power section mounted downstream of the inlet section with said power member mounted therein, an outlet section mounted downstream of the power section forming an outlet opening, the outlet opening having a cross-sectional area greater than that of the inlet opening for decreasing the velocity of the water exiting when in use the device below that of the water entering while increasing the pressure of water in the housing and thereby permitting extraction of kinetic energy by said power member from the restricted portion of flowing water for conversion to usable power by said power generating means, and an outside wall displaced from the inside walls to hold sufficient quantity of air to provide neutral buoyancy to the device when submerged with the flowing water.

11. A submersible device for use in converting the power provided in flowing water, comprising:

a power member capable of being moved by flowing water;

generating means mounted with said power member for converting the movement of said power member into power; and

a housing mounted around said power member for restricting a portion of the flowing water, said housing having walls which define

an inlet section forming an inlet opening, a power section mounted downstream of the inlet section with said power member mounted therein, an outlet section mounted downstream of the power section forming an outlet opening, the outlet opening having a cross-sectional area greater than that of the inlet opening for decreasing the velocity of the water exiting the device when in use below that of the water entering while increasing the pressure of water in the housing and thereby permitting extraction of kinetic energy by said power member from the restricted portion of flowing water for conversion to usable power by said power generating means, the inlet section and the power section being positioned laterally transverse relative to each other and having a power section opening therebetween for enabling water flow through the inlet section into the power section, and said power member including a shaft rotatably mounted and positioned longitudinally in the power section and a plurality of outwardly extending blades with each blade having first and second sections, the first section of each blade being positioned transverse to the flow of water through said power opening and the second section of each blade forming at least a portion of a helix and being positioned parallel to the flow of water through said power section wherein in use flowing water entering through said power opening rotates the shaft by hitting said first section of each blade positioned normal to said water flow and the water is turned in said power section to flow longitudinally therethrough and further rotate the shaft by hitting said second section of each blade while flowing longitudinally through said power section.

12. A device according to Claim 11, wherein the outlet section has an inlet opening and an outlet opening which are positioned transverse to each other and wherein the outlet opening of the outlet section is positioned parallel to the inlet opening of the inlet section.

13. A submersible device for converting the power in flowing water, substantially as described herein, with reference to Figures 1 and 2, or Figures 3 and 4 of the accompanying drawings.

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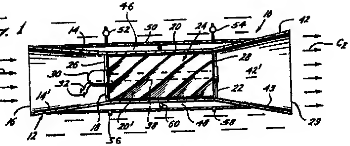
Fig. 1



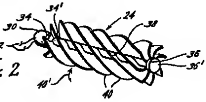
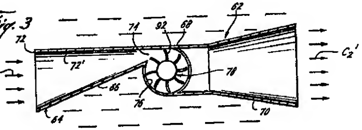


Fig. 2

Fig. 3



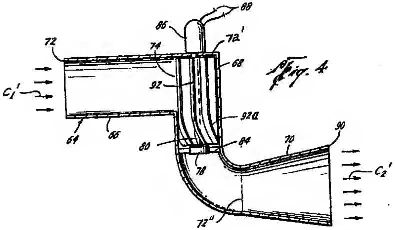


Fig. 4